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ABSTRACT

This unit, developed by the Third World Science Project, is designed to add a multicultural element to existing science syllabi (for students aged 11-16) in the United Kingdom. The project seeks to develop an appreciation of the: boundless fascination of the natural world; knowledge, skills, and expertise possessed by men/women everywhere; application of knowledge and skills to solve the practical problems of everyday life; impact of modern technology in the world; and the influence of the cultural background on the perception of knowledge, problems, and solutions. The unit begins with an outline of the methods used in Zambia to produce charcoal from skillfully constructed log piles. An extract from the Technology Consulting Centre at Kumasi on charcoal burning follows, as well as a report of charcoal burning in Sri Lanka. A contribution on charcoal burning by a third year pupil of Lubushi Seminary in Zambia is included, together with some experiments on the small-scale preparation of charcoal. Suggested practical work includes collection of volatile vapors and the measurement of temperature porosity of charcoal. (JN)

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CHARCOAL

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THIRD WORLD SCIENCE

Third World Science seeks to develop an appreciation of:

- 1 The boundless fascination of the natural world
- 2 The knowledge, skills and expertise possessed by men and women everywhere
- 3 The application of knowledge, skills and expertise to solve the practical problems of everyday life
- 4 The impact of modern technology in the third world
- 5 The influence of the cultural background on the perception of knowledge, problems and solutions

The following Units have been designed to fit into existing science syllabuses in the United Kingdom:

CARRYING LOADS ON HEADS: CHARCOAL: CLAY POTS:
DENTAL CARE: DISTILLATION: ENERGY CONVERTORS:
FERMENTATION: HOUSING: IRON SMELTING: METHANE DIGESTORS:
NATURAL DYES: PLANTS AND MEDICINES: SALT: SOAP.

The method of use is not closely prescribed. As resources teachers may use them in different ways though suggestions are offered. Feedback is invited from teachers concerning (a) the use made of the material (b) pupils reactions, if possible in their own words, and (c) suggestions for improvements, additions etc.

Please send feedback, ideas and requests to:

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CHARCOAL

Teacher's Notes

The use of wood as a chemical raw material and as a renewable energy source seems to be a viable option for the future particularly for tropical countries.

In developing countries, interest in charcoal as a fuel, both for domestic use and for industrial purposes, has increased because of the steep rise in the prices of all fuels and power.

The unit begins with an outline of the methods used in Zambia to produce charcoal from skilfully constructed log piles. Despite the construction of new kilns made of metal, they are not being adopted as quickly as expected by the charcoal industry due to operational difficulties and the expense of buying them. The techniques of producing charcoal by the traditional method are described. This information could be used in conjunction with a lesson on destructive distillation or about charcoal as one of the allotropic forms of carbon.

An extract from the Technology Consulting Centre at Kumasi on charcoal burning follows, as well as a report on charcoal burning in Sri Lanka.

A contribution on charcoal burning by a third year pupil of Lubushi Seminary in Zambia is included, together with some experiments on the small-scale preparation of charcoal.

Further practical work could involve the collection of volatile vapours, measurement of temperature porosity of charcoal, etc.

CHARCOAL

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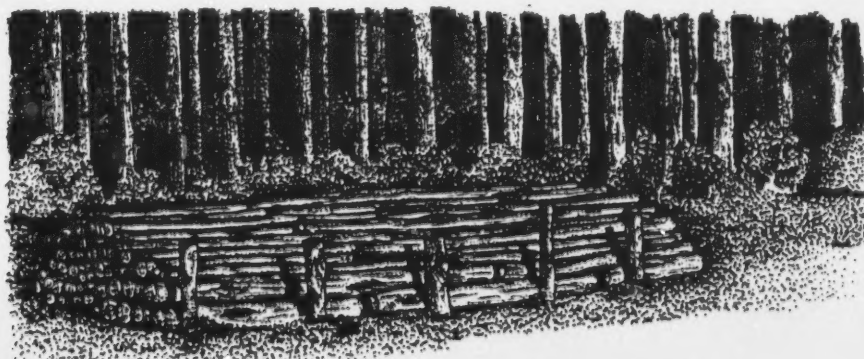
CHARCOAL

Charcoal making is an ancient practice in this country and all over the world, however the availability of coal and oil has diminished its importance in this country. In many developing countries there are no coal deposits and very little foreign exchange to purchase oil; the only energy available apart from the sun, is wood.

Wood is more efficient for cooking with when it is converted to charcoal. Many years ago charcoal was produced in Britain in simple kilns which were no more than piles of logs covered with leaves and earth. In developing countries today this process is maintained (see fig 1 & 2). It requires skill and expense to make charcoal, because of the critical factors involved during the building of the pile and also while the wood is being converted to charcoal.

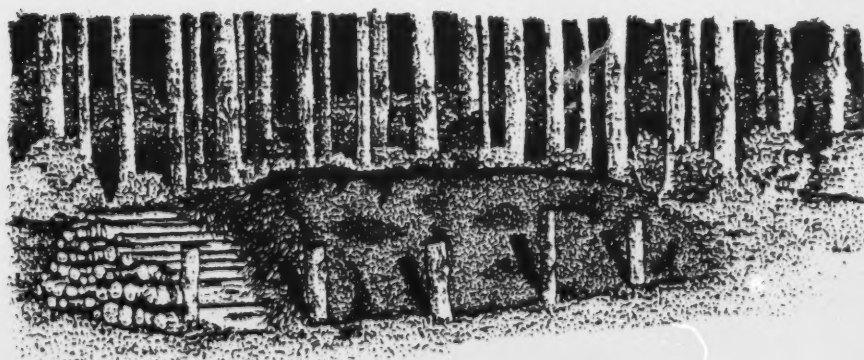
The ventilation is critical - too little and the wood is left unconverted, too much and it is burnt to ash. About 10% of the wood is converted to charcoal by this method.

FIG. 1



LOG PILE BEING CAREFULLY BUILT.

FIG. 2



LOG PILE COVERED WITH BRANCHES AND TURF.

New kilns have been designed for use in developing countries which give a better yield of charcoal, converting between 20-25% of the wood (see fig 3). These new kilns are usually made of metal. However they are not being adopted as quickly as one would expect by the charcoal industry, some of the reasons being that the kilns are more difficult to operate, expensive to buy and in areas where wood is cheap there is little incentive anyway.

FIG. 3.

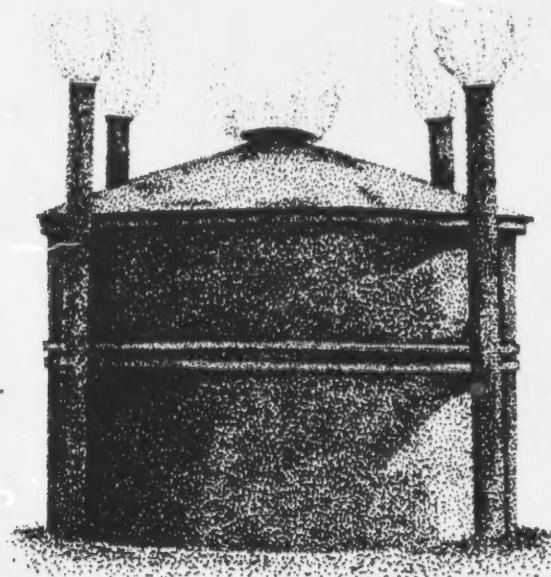


FIG. 4.

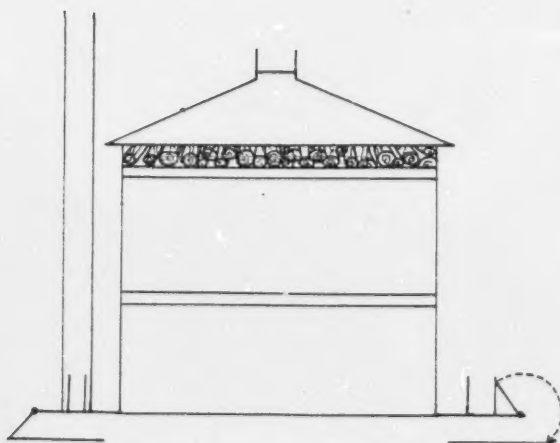
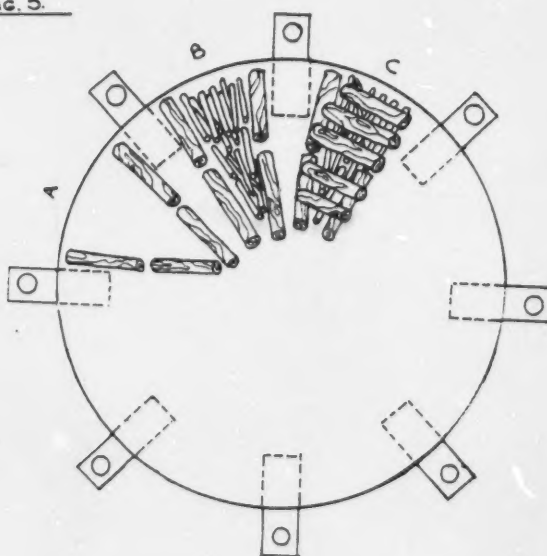


DIAGRAM OF CHARCOAL KILN.

FIG. 5.



STAGES OF STACKING WOOD IN A CHARCOAL KILN.

Techniques of Producing Charcoal Using Traditional Method

The actual production of the charcoal may be conveniently divided into four parts.

(i) Cutting and stacking of the timber

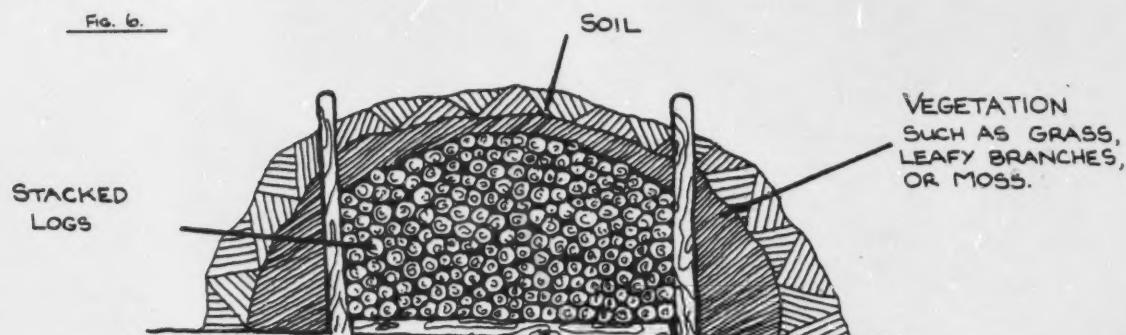
Once the tree has been cut down and the branches removed, the wood is cut into lengths of about 1.5 metres. The largest suitable diameter used is about 1.3 metres and the smallest diameter about 0.1 metre, any smaller and the wood is likely to burn to ash. The wood is stacked into piles with the largest diameter wood on the bottom.

The piles vary a great deal in their sizes. When timber is readily available, the piles may be 2 metres high and up to 6 metres long.

(ii) Covering of the piles

In order to limit the amount of air which can enter a pile once it has been lit, the pile is next covered with leafy branches or grass and then this is covered with soil. Sometimes it is only covered with turf.

This turf is obtained from an area as close to the pile as possible and is cut by means of a hoe. Figure 6 shows the cross section of a finished pile.



(iii) Burning the pile

In practice, burning is the last thing a burner wants to happen to his wood.

During the covering of the wood, a small opening, exposing some of the wood is left at one end of the pile. This is filled with grass, twigs and any other inflammable material which is readily available. The material is set alight and once the burner is satisfied that it has caught alight, the opening is covered with turf. From this point on in the process, the skill of the charcoal burner comes very much to the fore.

In theory, what should happen in the pile is that a small amount of the wood should burn and produce sufficient heat, to heat (not burn) the remainder of the wood and convert it to charcoal. This is much easier said than done in this rather crude form of destructive distillation.

Too slow a rate of heating may mean that the burner will obtain a high conversion ratio, but the process is likely to take too long and also the charcoal produced will probably contain large quantities of volatile material not acceptable to the final buyer.

Too high a rate of heating will produce charcoal quickly, but in poor yields and also the charcoal is likely to be contaminated with ash.

Thus, the skill and experience of the burner will play a large part in determining the success or failure of the process. The pile must be carefully watched and the covering altered so as to allow for changes in wind, temperature, rainfall and the many other factors which can alter the rate of combustion.

The most serious calamity which is likely to occur during this stage, is the partial collapse of the covering. As this exposes the wood to the air, very quick action on the part of the burner is needed if he is not to lose a lot of his wood as ash.

In addition to the continual production of smoke, the most noticeable feature of the burning process is the decrease in the size of the pile. This decrease is first noticed at the end of the pile where burning started. As burning proceeds along the length of the pile, so does the decrease in height. This change in height is used by the burner as an indication as to how far the process has passed along the length of the pile.

In general the pile decreases to about two thirds of its original height during this process.

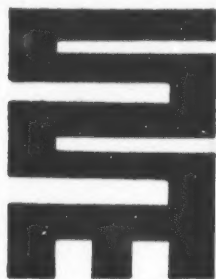
(iv) Collection of charcoal

Once the burning has been completed - shown by the lack of smoke and the decrease in height along the whole length of the pile - the pile is allowed to cool for a day or two. If it were opened immediately, it would probably catch fire because the charcoal remains at high temperature for some time.

The charcoal is carefully collected and put into bags to be sold.

The whole process from cutting to collection takes about two weeks depending on many factors.

TECHNOLOGY CONSULTANCY CENTRE



University of Science
and Technology,
KUMASI,
GHANA.

APPLYING SCIENCE TO INDUSTRY IN GHANA.

EXTRACT FROM T.C.C. REPORT ON CHARCOAL BURNING

TRADITIONAL CHARCOAL BURNING

Traditional charcoal burning has remained unchanged for many years. Most people are familiar with the activities of the traditional charcoal burners. Their smoking kilns are to be found near sawmills in the cities and near logging sites in rural areas of the forest zone. The charcoal burners make a large pile of suitable sized pieces of waste wood which is ignited and covered with pieces of bark, sawdust, leaves or earth. The fire is allowed to burn slowly for a period of about a week. During this period the airflow to the fire is controlled through holes arranged around the base of the pile. When the process is judged to be complete the holes are plugged and the pile is allowed to cool down before it is opened. This is necessary because hot charcoal can re-ignite when exposed to the air. After opening the pile the charcoal is collected and placed into sacks for dispatch to the market.

The traditional method of charcoal burning has remained unchanged for many years. It undoubtedly possesses some advantages. It can be undertaken with a very small capital investment because its apparatus is made from low cost materials and its raw material is a waste product. The process is very inefficient but the inefficiency is not apparent because the raw material is so abundant and cheap. The industry provides a good service in supplying the bulk of fuel used for cooking in the urban areas. It also produces a high grade charcoal made from palm kernels which is used by blacksmiths and other rural craftsmen.

CARBONISATION

Wood is an organic material containing carbon, hydrogen and oxygen and many other elements in smaller quantities. It is not homogeneous in structure or chemical composition and it contains many substances with complex formulae. However, one of the most common substances is called cellulose and has a formula $(C_6H_{10}O_5)_n$ where n is greater than 3500. Cellulose is the most abundant natural organic material and is found in plant cell walls. In wood it occurs in the pulp.

When wood is heated in the absence of air much of its substance becomes volatile and is given off as gas. Most of what remains behind in the solid state is carbon and this is what is known as charcoal. The process is called carbonisation, destructive distillation or pyrolysis. If air is completely excluded and the temperature is carefully controlled the quantity of charcoal obtained may exceed 25% of the original weight of the wood. Some species of Ghanaian hardwood are said to be capable of yielding 30 to 40% by weight of charcoal.

In the traditional charcoal kiln, air is not completely excluded and neither is the temperature controlled with sufficient precision. As a result, the yield of charcoal is typically in the range 5 to 15% with an average of about 10%.

IMPROVED CHARCOAL KILNS

In most practical charcoal kilns the heat is provided by the partial combustion of the wood. If the air supply is suitably restricted the wood does not burn to ash but remains as charcoal. Too much air yields more ash and less charcoal while too little air leaves some raw wood unconverted. To effect a very precise control of the airflow it is necessary to construct a scientifically designed kiln made from steel, brick or other engineering material. Several types of improved kilns have been tested in Ghana. One of the most successful was the Tranchant kiln which is portable and made of steel. While under test it gave a yield of 20-25%.

One might have expected that the Tranchant kiln would be quickly adopted by the charcoal burning industry. However, it was found to be unpopular and the kilns were abandoned when they needed repair. Some of the reasons are thought to be as follows:

- a) The establishment of a loan scheme to finance the purchase of the kilns.
- b) The establishment of a chain of workshops to repair and later to manufacture new kilns, and
- c) The establishment of a training scheme to teach the charcoal burners how to get the best out of their new kilns.

However, even with all these services the new technology might only become popular when some economic factor renders the new kiln considerably more profitable than the old kiln. This could happen, for example, as wood becomes scarcer and more expensive so that the higher efficiency of the new kilns offers a clearly perceived advantage. Another factor in favour of a new technology might be the availability of a new attractive product.

PYROLYSIS

When wood or other organic material is subjected to destructive distillation the gases which are given off are of two kinds; condensable and non-condensable. The condensable gases include water and a thick black oil called pyrolytic oil. It is possible to condense the pyrolytic oil without contamination with water, if the condensing temperature is maintained above the dew point of about 80°C. The pyrolytic oil can then be used as a fuel of calorific value equivalent to mineral oil known as bunker grade C which is used in power stations, ships and industrial kilns of various types.

The Technology Consultancy Centre of the University of Science and Technology, Kumasi, has built a pyrolytic convertor which burns sawdust and produces both charcoal and pyrolytic oil. The pyrolytic oil is intended to be used in a brick kiln operated at Fumesua, Ashanti, by the Building and Research Institute.

The non-condensable gas produced by the pyrolysis plant can also be used as a fuel since it contains about 50% methane. In the Fumesua plant, the gas will be burned to dry the sawdust feed for the pyrolytic convertor.

The Scientific carbonisation of wood compares to the traditional process as follows:

	<u>Pyrolytic Convertor</u>	<u>Traditional Kiln</u>
Charcoal yield	25%	10%
Oil yield	10%	NIL
Gas yield	5%	NIL
	—	—
	40%	10%
	==	==

The percentages of the products of the pyrolytic convertor can be varied somewhat by adjustment of temperature. However, the total yield of fuel remains reasonably constant.

T E C H N O L O G Y

Sri Lanka's energy problem comes out of the woods

Sri Lanka could soon become an energy exporter with a scheme that will also increase its area of arable farmland. The country's Foreign Investment Advisory Committee plans to turn an embarrassment of waste wood into charcoal. The fuel could power the local cement industry or could even be exported, for instance to Japan and Saudi Arabia.

During the past few years, Sri Lanka's foresters have cleared the giant Mahaveli forest to create new, irrigated croplands. Although cash for the project has been no problem-- the World Bank has helped out - the Sri Lankans have been left with a lot of wood from felled wira trees. Wood, together with kerosene, is the nation's main domestic fuel, but the 25 million tonnes of wood that the forest will provide within the next five years is a long way from towns and villages, and so is too expensive to transport. Traditionally, foresters burn it on the spot or leave it to rot.

But when it is converted into charcoal the wira becomes a much lighter and more efficient fuel. So a new company, Charlanka, will work with Enterprise Development Incorporation of Washington DC and the Sri Lanka State Timber Corporation to exploit this rich source of energy.

To help the Sri Lankans to develop an efficient means of producing charcoal, Garry Whitby of Intermediate Technology Industrial Services (ITIS) in Rugby has supervised trials with wood kilns this year. ITIS collaborated with Shirley Aldred Engineering, a British company that has been manufacturing a portable steel kiln, in co-operation with Peter Hock, a consultant. "The new kiln is expected to produce around 800 kg a 'burn', although test have given 900 kg of usable charcoal," says Whitby.

Each kiln is an inverted cone of steel rings. It lasts for three years, and costs about £500. Villagers would find them more efficient than traditional earth furnaces. Charlanka also believes that the cost of making charcoal in the kilns will encourage the Sri Lanka Cement Corporation to substitute the fuel for some of the 300,000 tonnes of coal it imports each year. And the company also estimates that the kilns will produce a surplus of 15,000 tonnes of charcoal each year for export.

The timber corporation has joined the scheme to promote sales of its own wood-burning stoves. The government recently removed all subsidies from sales

of Sri Lanka's other important domestic fuel, kerosene. But the country's Institute of Scientific and Industrial Research cited important medical reasons for promoting charcoal as a smokeless fuel: it could, claims the institute, cut the number of cases of eye, skin and lung diseases that Sri Lankan women commonly suffer in unventilated kitchens.

People who live within 200 km of the kilns will receive the charcoal; the cost for transporting wood become too high when forests are more than 80 km from a village. This will make the Mahaveli's charcoal available to 200,000 people and will provide employment in rural forest areas, although Charlanka has not yet decided who will own and run the kilns.

Not all of the cleared forest will become farmland. Within five years, foresters will plant 14,000 hectares of fast-growing eucalyptus trees to replace the wira as sources of charcoal run out.

PROJECT: CHARCOAL BURNING

Not all types of wood can be used to make charcoal. The requirements needed in wood so that a better yield of charcoal is obtained are;

The wood must be hard.

The wood should not contain large amounts of volatile matter.

It should not tend to burn, even when heated in a limited supply of air.

The charcoal produced from the wood must have sufficient mechanical strength so that the charcoal does not easily crumble while being moved about for sale.

The ratio of the volume of charcoal produced should be high to the volume of wood.

A better quality of charcoal can be made from the following trees:

Muputu

Mupundu

Mutondo

Muombo

These are all hard woods containing no volatile matter in them.

Cutting and Stacking of the Timber

Process: Once a tree is cut down, it's cut into lengths of about 1.5 metres, wood of smaller diameter is likely to burn to ash during the burning process.

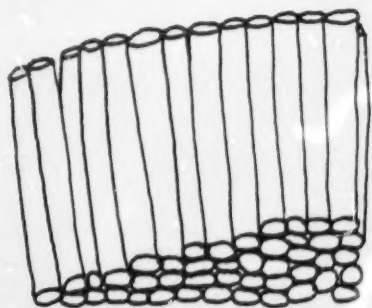
When sufficient lengths are available the wood is then stacked into piles.

Covering the Pile and Burning

The pile is covered with a layer of turf in order to limit the amount of air once it has been lit. Then the pile again is covered with a layer of earth. The earth can either be wet or dry. During the covering of the wood a small hole exposing some of the wood is left at one end of the pile. This hole is filled with grass and any other material which is inflammable. This material is lit and once it has caught fire the hole is covered with turf. What should happen in the pile is that a small amount of wood should burn and produce enough heat (not burn) the remainder of the wood and convert it to charcoal.

To produce a better yield of charcoal care is taken to control temperature. If the rate of heating is too high the charcoal will quickly be produced but

Preparation of Wood
for
Charcoal Burning



STACKING THE PILE.

Fig. 1.

COVERING THE PILE.

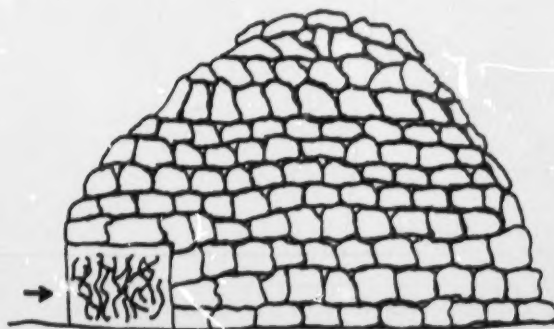
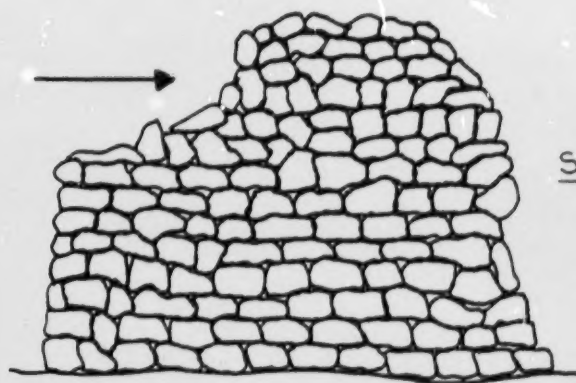


Fig 2.

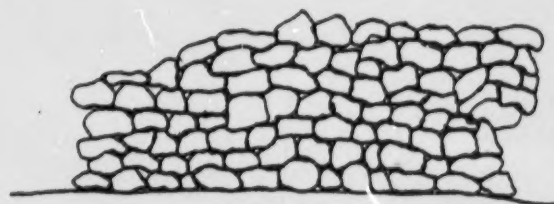


SHOWING DIRECTION OF BURNING.

Fig. 3.

THE PILE COLLAPSES.

Fig.4.



in poor yield. The charcoal too will be contaminated with ash. Rainfall and wind should also be controlled or they will alter the rate of combustion. Should too much air enter the pile, the wood will burn to ash. The changing of wood to ash is known as a chemical change since we don't get the wood back from it.

Because the pile is supplied with a limited supply of oxygen, carbon dioxide is produced. The rising of this gas from the pile is a sign to tell that wood is being heated to make charcoal. A serious calamity that might occur during this stage is the partial collapse of the covering. This will expose the wood to air; and will result in losing a lot of wood to ash.

The decrease of the pile shows how far the wood has undergone burning.

The burning period lasts from seven to eight days.

Collecting of the Charcoal

When the burning is completed as indicated by a lack of smoke and a decrease in height along the whole length of the pile, the pile is allowed to cool for about a day. If it's not cooled and yet we open it; it will immediately catch fire because the charcoal is still at a high temperature.

The whole process of making charcoal in Zambia, is known as "destructive distillation". Vapours are given out during this process.

Use of Charcoal

Used for cooking.

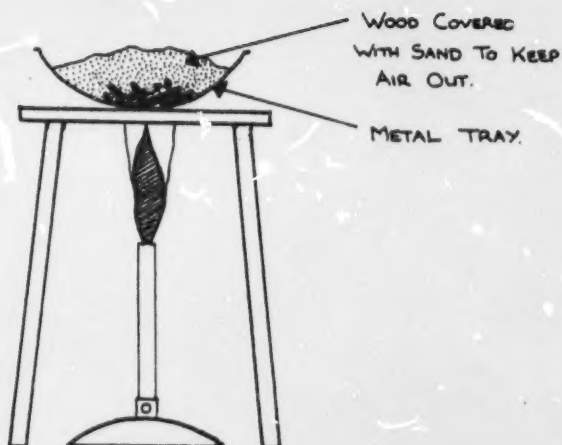
Charcoal has the property of removing coloured impurities from final products.

Used in the purification of sugar.

Used for smelting metal, e.g. copper and iron.

SMALL-SCALE PREPARATION OF CHARCOAL

Method 1



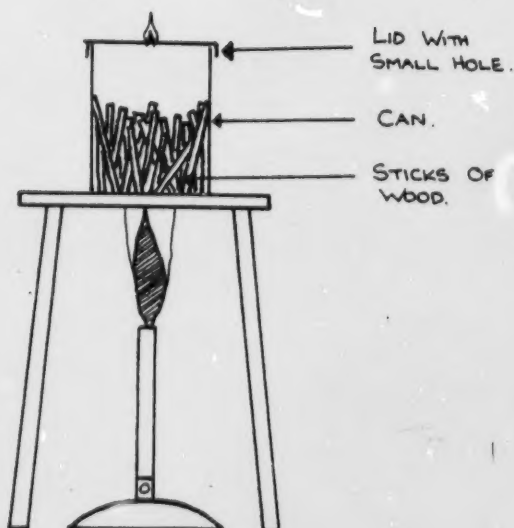
When do you think that all the wood has turned into charcoal?

Has all the wood turned into charcoal?

Try the experiment using different kinds of wood.

What type of wood is best for making charcoal?

Method 2

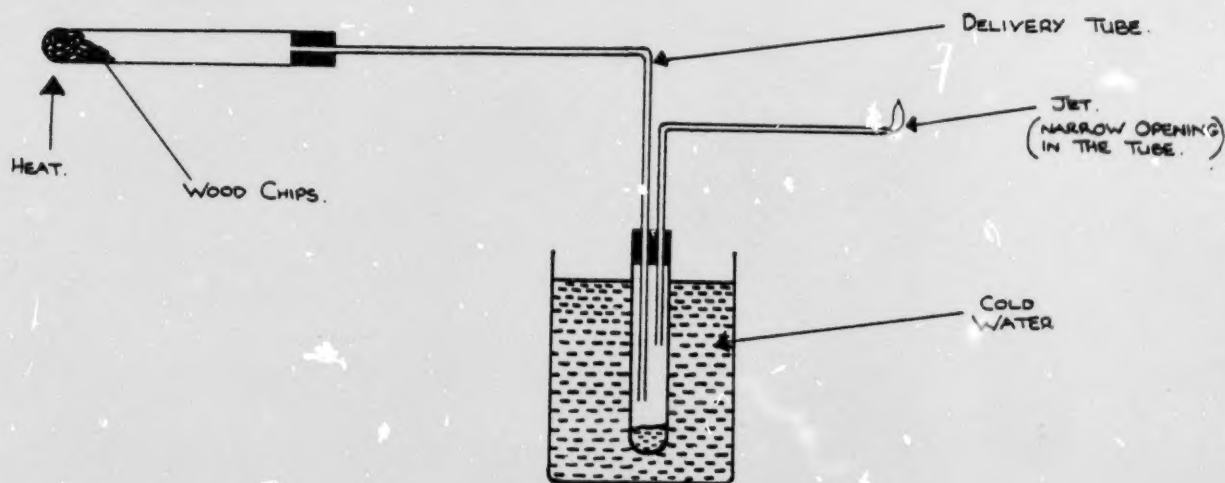


What is the gas coming out of the hole in the lid?

What similarities are there between making charcoal in the laboratory and traditional charcoal making?

Place some powdered charcoal in a test tube containing 'purple' methylated spirits and shake. What happens?

Method 3



Heat the wood gently at first, then steadily increase it. Ensure that the heat is distributed around the wood chips in the tube.

Apply a lighted splint to the jet when a smoky vapour is observed.

Notice what collects in the bottom of the tube in the cold water.

Questions

- 1) What gas is being burnt at the jet?
- 2) What has happened to the wood chips?
- 3) What has collected in the bottom of the test-tube in the cold water? Test it with pH paper. Try and find out what substance this is.
- 4) Find out what the oil and gas can be used for.
- 5) Suggest a way that a portable steel kiln could be adapted to collect the volatile vapours.

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THIRD WORLD SCIENCE

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Writers: Natalie Jones, Wyn Hughes Typing: Marjorie Eccles
Graphics: Karen Moss

In this phase of the project 100 sets of 14 Units have been produced and distributed to schools, teachers' centres and teacher training establishments. Draft material has been prepared for further Units.

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